LCA in China

Material Life Cycle Assessment in China

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Abstract. From the very beginning, the research of Material Life Cycle Assessment (MLCA) has been an important part of the eco-materials research in China, and large numbers of researchers have been focusing their efforts on it. From 1998, and supported by the National High-tech Program-863 Projects, the study of some typical materials has been put into practice. Thus far, the first phase of the project has been finished smoothly. The practical MLCA methods have been developed, and the manufacturing technologies and processes of the steel and iron, aluminum, cement, ceramic, polymer and construction coatings have been assessed. The relevant assessment software has been developed. Reference systems are being set up for evaluation by studying typical materials. In this paper, the main achievements are reviewed. Some other developments of MLCA in China are also introduced.

Keywords: China; environmental load; LCA; life cycle inventory; material life cycle assessment (MLCA); MLCA

Introduction

Material is one of the foundation industries for the development of society and economy. For the production, manufacture, application, and disposal processes of materials, numerous energy and resources are seen to be consumed, and environment deterioration is observed as well. To coordinate material development with environmental protection, a sustainable development of eco-materials has been developed in the world since the beginning of the 1990s [1-3]. The research of eco-materials in China began at that time. Many efforts from universities, industry and national laboratories have focused on this topic, together with the guidance and support of the government. The research of Material Life Cycle Assessment (MLCA) was especially emphasized. There is still a lot of work to be done concerning the LCA method. Developing the basic database and related standards suitable for China is also one of our research orientations [4].

Supported by National High-tech Program-863 Projects, the study of environmental loads related to the basic database of some typical materials, including metals, cement, ceramics, polymers and so on, has been put into practice. Thus far, the first phase of the 863-Project of MLCA has been finished smoothly. With the cooperation of universities and industries, the practical MLCA methods have been developed, and the manufacturing technologies and processes of the typical materials have been assessed by these methods as well.

In the following, the achievements in this 863-Project are reviewed. In section 1, a description of the assessment of the typical materials is given. The assessment results are given separately according to the kind of the materials. Section 2 gives the progress on the research of MLCA methodology. Section 3 presents some results on the establishment of the basic environmental load database and the development of the assessing software. In the end, a brief summary is provided.

1 Assessment of the Typical Materials

In the 863-Project, the manufacturing technologies and processes of the steel & iron, aluminum, cement, ceramic, plastic and construction coatings have been assessed by the MLCA methods, and the developments are introduced as follows:

1. Iron and steel. Focused on the low carbon steel, high alloy steel and commonly used products such as ferromanganese, ferrosilicon and ferrotungsten, the processes of BF/BOF, scrapped steel/EAF process and COREX-DRI/ERF process are mainly investigated. The data of material consumption, energy consumption and waste emission related on these processes are collected and the life cycle assessment of them is performed.

2. Cement. The flows of a pre-decomposition kiln, vertical kiln, and wet kiln are chosen and investigated. This is the first time that the typical processes have been analyzed so extensively and so deeply in China using the MLCA method. The method adopted maintains the advanced world standards, and the national conditions are taken into account in the practical assessment. The results of assessment are analyzed intensively, and some reference is given to the interrelated research. In order to improve the ulterior MLCA research, some useful suggestions are also presented.

3. Aluminum. The typical alumina production using a sintering process and combined Bayer-sinter process, and the aluminum production with the prebaked cell and selfroasting cell, are selected as an emphasis for this investigation. In order to make a cross-sectional and longitudinal comparison with the different processes, attention is paid not only to the deepness and broadness of the data of environmental load, but also to the relation between the environment, economics and technology. A lot of related data about has been collected which paves the way for the comprehensive life cycle assessment.

4. Polymer. Some of the typical polymer, including ethylene, polyethylene, SAN, EPS and ABS and natural plant fiber, are analyzed using the MLCA method. The environmental loads

of the high molecular materials and the natural plant fiber are compared. According to the assessment results, some improvement measures are also discussed. The problems of environmental loads of multi-product and multi-branch systems are resolved.

5. **Construction Coating.** The methods for the collection of environmental load data, as well as the quality assessment of these data, are given. With the help of related enterprises of production and the local government, lots of basic data has been collected. Furthermore, the life cycles of polyacrylic acid latex paint and the polyurethane waterproofing paint are analyzed, and the environment loads are assessed separately.

6. **Ceramics.** SiC heaters (siliconit), including thick-end and equal-diameter siliconit, are selected as the typical engineering ceramic products. Large quantities of data of material consumption, energy consumption and waste disposal have been collected, and the most important stages of the production have been identified. The environmental loads of the two processes, including new and traditional processes, has also been analyzed and compared. The research on the environmentally-conscious ferroelectrics is undertaken on the basis of the development tendency of eco-materials and the demand for life cycle assessment. The important advancements in the BNT [$(Ba_{1/2}Na_{1/2})TiO_3$] and $NaNbO_3$ series have been considered as well.

2 Research on Methodology of MLCA

On the methodology of the MLCA, some achievements have been made in the following:

1. **Life Cycle Inventory Survey Table.** A 'Life Cycle Inventory Survey Table' is set down for the typical materials. The normalized table provides the foundation for the collection of such multifarious environmental load data.

2. **Computation Method for MLCA.** A new computation method for MLCA is put forward. Regarding a certain material process as a black box, the final environment impact can be assessed quantitatively based on the input and output parameters. Generally, these parameters include the consumption of natural sources and energy sources and the discharge amount of the wastes.

3. **Influence Rule of Weighting Factor.** The effect of the weighting factor on the total environment impact is discussed in the processes of the shaping and heat-treatment of metals. The regular pattern of such effects and the methods of determining the coefficient values are discussed.

4. **Definition of Weight Coefficient by Degree of Relation.** A new method aimed to estimate the weight coefficient is brought forward. This method is based on the association degree of life cycle inventory data in different years, and can reflect the macroscopic differences to the assessment factors because of the technical progress.

5. **Standard Flow Comparing.** A novel methodological approach called Standard Flow Comparing was developed. Since the approach gets the assessment results by comparing environmental impact parameters of actual industrial flow with that of Standard Flow, it avoids calculating the absolute value of environment impact. Furthermore, the approach can reflect the technology issue of the subject investigated, and can accelerate the adoption of high and new-technology industries.

6. **Synthetic Scale Factor.** A novel method of quantification assessment, which is a Synthetic Scale Factor, is given. The method can determine the environmental impact of pure metal, and can then calculate the impact of metallic materials. The advantage of the method lies in its credible mathematical principle, its simple and convenient formula, and the balance of the main factors and the subordinate ones.

7. **Whole Life Cycle Assessment.** In order to perform a life cycle assessment (LCA) of continuity and cumulation, a new concept that is named 'Whole Life Cycle Assessment (WLCA)' is put forward. According to the new concept, MLCA and PLCA equal WLCA. That is, MLCA+PLCA=WLCA. The concept of WLCA has important academic significance.

3 Database and the Assessment Software

Due to the great variations of geology, resource, industrial structure, and technical standards in different countries, developing the basic database and related standards suitable for China has become one of our research orientations. To date, the basic database of typical materials in China has been established primarily. The relevant assessment software has also been developed. The elements in the LCA system are operations, resultants, environmental burdens and the environment [5]. Reference systems are set for evaluation by studying typical material life cycles.

4 Summary

Through the support of the national 863-project, CCMLCA (Chinese Center for Material Life Cycle Assessment) has been established at the Beijing Polytechnic University. The CCMLCA has been carrying on lots of international collaboration with universities and research communities in Europe, Canada and Japan on the research of eco-materials and MLCA, and has come to agreement with some of them.

As well as eco-materials, the MLCA study is a research and development issue not only involving natural sciences but also social sciences. To perform the environmental education of eco-materials and MLCA in depth, relevant courses have been offered in many universities for undergraduates, post-graduate students, and even doctoral students. Furthermore, several relevant monographs for research and propaganda have been published.

Acknowledgements. This research is financially supported by a grant from the National High-tech (863) Program of China. The authors also thank the following universities for their fruitful cooperation: Chongqing University, Beijing University of Aeronautics & Astronautics, Tsinghua University, Lanzhou University, Xi'an Jiaotong University and Sichuan University.

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